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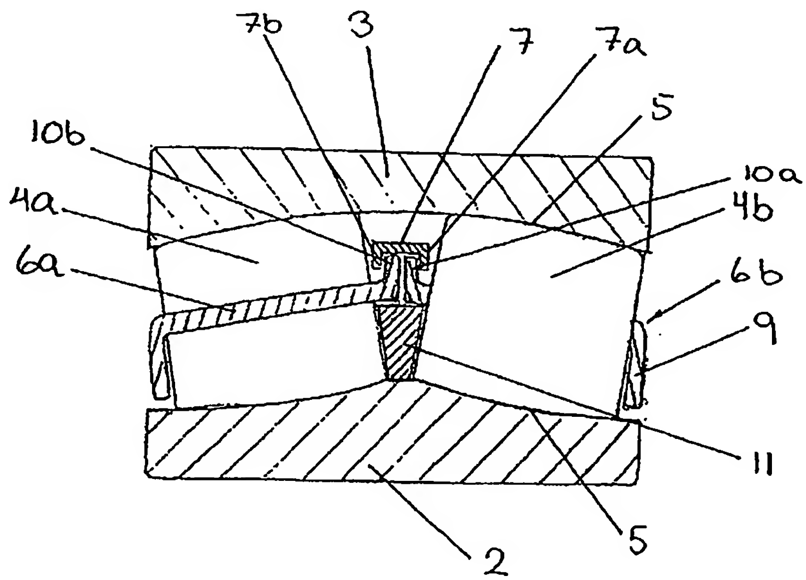

(57) Abstract: The invention relates to spherical roller bearings and particular preferred embodiments of the invention relate to transmissions having spherical roller bearing according to the invention. The invention aims at ensuring that the rollers of the two rows of rollers are not brought into position where they hinder compensation of misaligned axial rotation of the bearing's outer and inner rings relatively to each other by controlling the axial movement of the rows of rollers away from each other by use of a holding structure.

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A SPHERICAL ROLLER BEARING HAVING A HOLDING STRUCTURE FOR CONTROLLING AXIAL DISPLACEMENT OF TWO ROWS OF ROLLERS IN A DIRECTION AWAY FROM EACH OTHER

The present invention relates to spherical roller bearings and particular preferred embodiments of the invention relate to transmissions having spherical roller bearing according to the invention. Particular preferred embodiments of the invention aims at ensuring that the rollers of the two rows of rollers are not brought into position where they hinder compensation of misaligned axial rotation of the bearing's outer and inner rings relatively to each other. Preferred embodiments of the present invention aims at ensuring this by controlling the axial movement of the rows of rollers away from each other.

The present invention is applicable in many kinds of rotating machinery and has found to be particular useful in connection with transmissions for wind turbines, and in particular useful in connection with wind turbines typically being larger than 500 kW. It has been found that a high number of spherical roller bearings in transmissions for wind turbines are destroyed during operation of the wind turbine after a lifetime of the bearings being much shorter than what normally can be expected. The destruction of the bearings results in breakdown of the wind turbine gearbox. Until now, no explanation of the destruction of the roller bearings has been found and no design has been made which cures the problem.

The roller bearings of a wind turbine transmission are arranged in a pronounced dynamic environment and are exposed to vibration. Furthermore, the transmission, which is tilted typically around 6° relative to horizontal, is exposed to highly varying loads, typically varying from zero to maximum load in a few seconds. In addition, the rotational speed for some of the transmission's bearings is reduced with up-scaling of the wind turbines.

A typical prior art roller bearing used in wind turbine transmission is shown in fig. 1. It is known that this type of bearings is well suited for taking up large loads in cases where misalignment of the shaft relatively to the bearing house may occur. Furthermore, the bearing is able to take up axial loads. Fig. 15a and 15b show schematically the conditions of an unloaded bearing construction (fig.15a) and a loaded and deformed bearing construction (fig. 15b). The bearing construction of figures 15a and 15b is typically of the kind used in a planet gear of the kind shown in fig. 13 and comprises a bearing (B) housed in a wheel (W), a carrier (C) and a shaft (S). The arrows F indicates forces acting on the bearing construction and the arrows G indicates forces from gravity and inertial forces from vibrations. It has been found that during operation of the wind turbine at low power, one of the rows of rollers, e.g. the right row with reference to fig. 15a, is practically unloaded and is vibrated to the right until full contact between the inner ring, the outer ring and one or more rollers is established. As the bearing is not designed for such contact, the contact is asymmetrical and the contact surface is not ideal resulting in that the rollers is wedged between the inner and outer rings of the bearing. In case the bearing is abruptly loaded in a situation with wedged rollers, which abrupt loading typically also results in a distortion of the carrier resulting in bending of the shaft which in turn results in that the

bearing must take up a misalignment of the shaft relatively to the bearing house, as shown in fig. 15b, scuffing of the bearing surfaces will occur due to friction between the surfaces.

A suggested explanation as to why some machinery do never experience problems of the above mentioned kinds while other do, reside in the dynamics occurring during use of the bearings. With reference to fig. 1 it can be seen that when the inner or outer ring rotate then also the roller cages will rotate resulting in the generation of a centrifugal force acting radially outward on each roller. The centrifugal force will have a component, due to the geometry of the spherical outer ring, directed axially inward which tends to push the two adjacent rows of rollers towards each other, so that wedging may be avoided. However, this dynamic is depending on a substantial centrifugal force and in situations where the bearing rotates slowly, or the inner and outer rings rotate in opposite directions with similar or not very different rotational speeds, rotation of the rollers around the centre of the bearing will be small and no substantial centrifugal force is acting on the rollers which in turn may result in that the rollers wedge.
It is an object of preferred embodiments of the present invention to provide a roller bearing in which the rollers are prevented from being wedged between the inner and outer ring.

In accordance with the object of preferred embodiments a spherical roller bearing has been provided which preferably comprises

- an outer ring and an inner ring each being provided with confronting raceways,
- two rows of rollers arranged adjacent to each other in the annular space between the raceways;

and

- a holding structure adapted to controlling, such as preventing, movement of the two adjacent rows of rollers at least in axial direction away from each other.

The holding structure may preferably comprise a roller cage for each row of rollers, circumferential spacing the rollers in each row and keeping the rollers in a substantial fixed position relatively to the roller cage while at the same time allowing rotation of the rollers. Additionally or in combination thereto, the holding structure may preferably comprise an assembling ring co-operating with the roller cages, or at least a part thereof, to control movement of the roller cages relatively to each other at least in axial direction away from each other.

In particular preferred embodiments, each roller cage may preferably comprise circumferential distributed and radially extending inner projections abutting in an outward axial direction one or more members of the assembling ring thereby controlling the axial movement of the roller cages away from each other. Typically and preferably. the radially extending projections of the rollers cages extend also in axial direction towards the outer periphery of the bearing.

Additionally or in combination thereto, the one more members of the assembling ring may preferably comprise two radially extending flanges defining a groove in which the radially extending projections of both roller cages extend into or within.

The radially extending inner projections may advantageously and preferably also extend radially outwards. Alternatively, the radially extending inner projections may advantageously and preferably also extend radially inwards.

The assembling ring may preferably be shaped so as to serve also as a distance piece keeping the two rows of rollers apart.

In particular preferred embodiments of the invention, each roller cage preferably comprise a radially extending inner flange co-operating with the assembling ring to control the axial movement of the roller cages relatively to each other in axial direction away from each other, said inner flanges are preferably un-broken or slotted in radial direction.

Additionally, the assembling ring may preferably comprise an annular member having two rows of projections extending radially and abutting the inner flanges of the roller cages. Furthermore, the annular member may preferably comprise elongated slots, such as cut-outs. Additionally or in combination thereto, the radially extending projections are arranged in the vicinity of the elongated slots. In combination or alternatively thereto, the assembling ring may preferably extend in a curved manner in circumferential direction.

Preferably, the projections of one of the rows of projections are circumferential staggered relatively to projections of the other row of projections. Alternatively, the projections of one or the rows of projections may preferably be circumferential non-staggered relatively to projections of the other row of projections.

The radially extending inner flanges of the roller cages extend preferably radially outwards. Furthermore, the radially extending projections or the inner flanges of the roller cages extend radially inwards.

In general, the two roller cages engage with each other so as to control the axial movement of the roller cages away from each other in axial direction.

In particular preferred embodiments, the engagement of the two roller cages is provided by one of the roller cages comprises an inner groove, preferably defined by a fold, in which a flange of the other roller cage extends.

In further particular preferred embodiments, the holding structure comprises a roller cage for both row of rollers circumferential spacing the rollers in each row and keeping the rollers in a substantial fixed position relatively to the roller cage while at the same time allowing rotation of the rollers.

It is in general preferred, that the rollers are received in cut-outs being provided in the roller cages so as to keep the rollers in a substantial fixed position relatively to the roller cage while at the same time allowing rotation of the rollers.

In further preferred embodiments, the two roller cages are preferably made integral with each other.

In preferred embodiments according to the present invention, the holding structure may comprise a limiting piece arranged on each side of the bearing, wherein at least a part of the limiting rings abuts the end of the rollers to prevent movement of the two adjacent rows of rollers at least in axial direction away from each other. Preferably, the limiting rings may be arranged in between the outer and inner rings. Alternatively, the limiting rings may be arranged on the outside of either the inner ring or the outer ring, the outer side being preferably a surface facing in the axial direction of the bearing.

According to preferred embodiments the dimensions and/or arrangement of the holding structure may preferably be selected so that a gap being present between the rollers and the raceways of the outer and/or inner raceways when the outer and inner rings are arranged concentrically is not closed due axial movement, if any, in axial direction away from each other of the two rows of rollers.

Furthermore, the holding structure may preferably be adapted to allow a movement of the two adjacent rollers in axial direction away from each other being within 0,001 and 1,0 %, such as within 0,01 and 0,5 % of the width of the outer ring. The width of the bearing is preferably defined as the axial extension of the outer ring.

In another aspect, preferred embodiments of the present invention relates to transmissions, such as gearboxes, preferably comprising at least a first gear for increasing or decreasing the rotational speed of a mechanical element, said transmission comprising a number of gear wheels whereof at least some of the gear wheels preferably are suspensioned by one or more roller bearings according to the present invention.

In preferred embodiments of transmissions, the first gear is preferably a planet gear wherein the planets are interconnected by a carrier and suspensioned by roller bearings according to the present invention. Furthermore, one or more gear succeeding the first gear may preferably be suspensioned by roller bearings according to the present invention.

A particular preferred embodiment of the present invention comprises a wind turbine having a rotor being connected to a transmission being connected to a generator, wherein the transmission is of a kind according to the present invention.

The present invention, and in particular preferred embodiments thereof, will now be described in connection with the accompanying drawings in which:

Fig. 1 shows a cross sectional view of a prior art spherical roller bearing. In fig. 1 arrow A indicates the centrifugal force and arrow B indicates the component of the centrifugal force acting on a roller,

Fig. 2 shows a cross sectional view of a roller bearing according to a first preferred embodiment of the present invention,

Fig. 3 and 4 each shows a section of an assembling ring according to preferred embodiments of the present invention; the sections are seen from the centre and radially outwards;

Fig. 5 shows a cross sectional view of a roller bearing according to a second preferred embodiment of the present invention;

Fig. 6a and 6b each shows a section roller cage according to the second preferred embodiment of the present invention; fig. 6a is a perspective view of the section of the roller cage and fig. 6b is a view in radial direction towards the centre of the roller cage;

Fig. 7 shows a cross sectional view of a spherical roller bearing according to a third preferred embodiment of the present invention;

Fig. 8 is a side view of a spring washer according to the present invention and comprised in the roller bearing shown in fig. 7;

Fig. 9 shows a cross sectional view of a spherical roller bearing according to a fourth preferred embodiment of the present invention;

Fig. 10 shows schematically a section of a roller bearing according to a fifth preferred embodiment of the present invention;

Fig. 11 shows schematically a section of a roller bearing according to a sixth preferred embodiment of the present invention.

Fig. 12 shows schematically a nacelle of a wind turbine with a transmission according to the present invention

Fig. 13 shows schematically a transmission for a wind turbine according to the present invention,

Fig. 14 shows schematically a bearing according to the present invention in which two roller cages are made integral with each other,

Fig. 15a and 15b. show schematically dislocation and wedging of rollers in a prior art bearing due to vibrations resulting in scuffing of the bearing due to loading, deformation and friction between surfaces.

Fig. 16a and 16b show schematically a section of a roller bearing according to a seventh preferred embodiment of the present invention,

Fig. 17 shows schematically a section of a roller bearing according to an eighth preferred embodiment of the present inventinon,

and

Fig. 18 shows schematically a section of a roller bearing according to a ninth preferred embodiment of the present invention.

In Fig. 2 a first preferred embodiment of a spherical roller bearing 1 is shown. The bearing 1 comprises an inner ring 2 and a outer ring 3 and two rows 4a and 4b of spherical rollers 4. In the inner ring 2 and outer ring 3, raceways 5 are provided constituting abutment surfaces for the surfaces of the rollers 4.

A holding structure is provided in the bearing 1 for holding the rows of rollers 4a and 4b. The holding structure shown in fig. 2 comprises two roller cages 6, one for each row of rollers 6a and 6b, for circumferential spacing the rollers in each row. The holding structure further comprises an assembling ring 7. The roller cages 6 are each an annular shaped element having cut-outs each matching the size of a roller so as to keep the rollers in a fixed position relatively to the roller cages 6. Optionally, the roller cages may be given such a shape that the rollers are locked in a rotatable position in the cut-outs. Each roller cage 6 is provided with a radially extending inner flange 10a and 10b extending through out the periphery of the roller cage 6. Alternatively, radially extending teeth 10a and 10b, in stead of inner flanges 10a and 10b, preferably extending through out the periphery of the roller cage 6 may be provided. The two roller cages 6 are fixed relatively to each other in axial direction by the assembling ring 7 comprising two rows of teeth 7a and 7b extending radially inward with the inner flanges 10a and 10b arranged between as indicated in fig. 2. In case the roller cages comprises radially extending teeth 10a and 10b instead of inner flanges, it is preferred that the assembling ring 7 comprises flanges 7a and 7b defining a groove in which the radially extending teeth 10a and 10b extend.

The dimensions of the assembling ring 7 and the teeth 10a and 10b are chosen so that a firm fit between the teeth 7a and 7b and the inner flanges 10a and 10b is provided so as to enable rotation of one of the rows of roller, e.g. 4a, independently of rotation of the other row of rollers, e.g. 4b, while preventing the two row of rollers 4a and 4b from being displaced away from each other in axial direction.

It is preferred to bias the two inner flanges 10a and 10b towards each other in axial direction, and in order to provide such pre-tensioning the assembling ring 7 is preferably made resilient so that the teeth 7a and 7b press the two inner flanges firmly against each other in axial direction. Furthermore, the resiliency may preferably allow a small axial movement of the two rows of rollers in axial direction away from each other.

Referring to fig. 3, the assembling ring 7 is made resilient, or the resiliency provided by the elasticity of the material is enhanced, by providing elongated cut-outs 12 in a region between two adjacent teeth 7a and 7b. Referring to fig. 4, the assembling ring 7 is made resilient or more resilient by that the ring 7 in circumferential direction is extending in a curved manner with the two rows of teeth 7a and 7b being staggered. It is noted that in case the ring 7 in circumferential direction extends in a straight manner and the two rows of teeth are staggered, then the ring 7 will still be resilient, however in a stronger manner.

The roller cages 6 each comprising an outer flange 9 abutting the inner ring and typically serving the purpose of helping to keep the rollers in theirs positions in the roller cage in case the bearing is situating in a vibrating environment.

As shown in fig. 2, a bearing 1 according to the present invention may preferably comprise a distance piece 11 to prevent the two rows of rollers from being displaced towards each other in radial direction.

Referring to figs. 5, 6a and 6b a second preferred embodiment of a bearing 1 according to the present invention will now be addressed. In this second embodiment, the bearing 1 also comprises a holding structure comprising two roller cages 6a and 6b with cut-outs for the rollers 4 and an assembling ring 7 having two flanges 7a and 7b defining a groove there between.

Each roller cage 6 comprises a radially extending inner flange 10a (10b) having radially extending inner projections 13. Four inner projections 13 equally distributed along a inner flange 10 are preferably provided on each roller cage but any number of projections may be selected, such as two, three, four, five, six, seven and eight equally distributed projections 13. When the holding structure is assembled these inner projections 13 extend within the groove defined in the assembling ring 7 by the flanges 7a and 7b.

The projections 13 are curved towards the cut-outs 14 to such an extend that they are bend away from the cut-outs 14, when inserted into the assembling ring 7. As the roller cages 6a and 6b are made from a material being resilient, the bending of the projections 13 when inserted into the assembling ring 7 will provide a resilient force pre-tensioning the two roller cages 6a and 6b towards each other in axial direction similar to the biasing described in connection with the first preferred embodiment of the present invention.

Alternatively, the inner projections 13 may instead of extending radially from the inner flanges 10a and 10b be provided by slotting the inner flanges 10a and 10b and curving the

thereby provided inner projections towards the cut-outs. When the bearing is assembled, the inner flanges 10a and 10b as well as the projections 13 extends within the assembling ring 7. In this embodiment also, four equally distributed inner projections 13 are provided but any number of equally distributed inner projections 13 may be provided as discussed above in connection with the first embodiment.

In this second embodiment, the assembling ring 7 is also designed to act as a distance piece keeping the two rows or rollers 4a and 4b distanced axially inwardly.

A further groove 29 is provided in the assembling ring 7. This groove may ease assembling of the bearings as one of the flanges 10a or 10b or both flanges may be introduced into the groove 29 during assembling of the bearing. Furthermore, the assembling ring may advantageously be provided with cut-out similar to those disclosed in fig. 3.

A third embodiment is disclosed in fig. 7. In this embodiment the holding structure comprises two roller cages 6a and 6b each having an outer flange 9a and 9b extending radially inwardly along the outer parts of the bearing 1, and an assembling ring 7 arranged on each side of the bearing 1. In fig. 7 two different alternatives of the assembling ring 7 is shown, on being in the form of a resilient washer and one in the form of a o-ring. The bearing may be provided with an o-ring on each side, an resilient washer on each side or a o-ring on one side and a resilient washer on the other side.

The assembling ring 7 according to this third embodiment is as shown in fig. 8 shaped as a spring washer comprising a number of teeth 18 provided in the outer rim of the washer encircling an inner section of the ring 7. When the assembling ring 7 is arranged as shown in fig. 7 the inner section of the ring abuts the outer surface of the inner ring 2 and the teeth 18 abut the outer flange 9b. As the teeth 18 are curved initially, they will provide a force on the flange 9b in the bearing's axial direction. As the o-ring 14 - or a resilient washer - on the other side of the bearing act as a counter pressure means and the distance piece is non-compressible, the two roller cages 6a and 6b and thereby also the two rows of rollers will be pre-tensioned in axial direction towards each other and the axial movement of the two rows of rollers in axial direction away from each other is controlled.

The assembling ring 7 is preferably kept in position by the environment in which the bearing is arranged, for instance kept in position by abutting a housing in which the bearing is arranged. Alternatively the assembling ring 7 may be fastened to the inner ring or being part of the inner ring.

A fourth embodiment of a roller bearing according to the present invention is shown in fig. 9. Also in this embodiment the holding structure comprising two roller cages 6a and 6b each having an outer flange 9a or 9b extending radially inward and each having an inner flange 10a or 10b. The assembling ring 7 comprises two flanges 7a and 7b extending radially inward thereby defining a groove. The bearing also comprises a distance piece 11.

As it appears from the above description of preferred embodiments of the present invention, roller bearings according thereto preferably comprise a distance piece 11 and it is contemplated that the various teeth and flanges of the assembling ring disclosed above may be provided in a distance piece as disclosed below and a separate assembling ring may be dispensed with.

Such an embodiment is schematically shown in fig. 10 showing two roller cages 6a and 6b, rollers 4a and 4b and a distance piece 11. The roller cages 6a and 6b each comprise an inner flange extending radially inwardly into a groove 15 defined in the distance piece 11 by two flanges 11a and 11b.

A further embodiment is shown in fig. 11. In this embodiment the axial movement of the two roller cages 6a and 6b is controlled by that the two roller cages engage with each other. The engagement of the two roller cages is provided by one of the roller cages comprises a fold 16 defining an inner groove in which a flange 17 of the other roller cage extends.

A further embodiment is shown in fig. 14. In this embodiment the two roller cages 6a and 6b are made integral with each other to form the holding structure as an integral piece.

As mentioned above another aspect of the present invention relates to transmissions and relates in particular to wind turbine transmissions. Fig. 12 shows schematically a wind turbine nacelle 22 (shown with the roof removed) mounted on a tower 23. In fig. 12 numerals 18 indicates the wind turbine rotor being rotatably connected to a transmission 19 via the main shaft 20. The main shaft 20 is connected to the low speed side of the transmission 19. The high speed side of the transmission 19 is connected to the generator 21 via a shaft.

The wind turbine transmission 19, or at least a first gear thereof, is shown schematically in fig. 13 and comprises, typically as a first gear, a planet gear 24 having three planets 25 and a sun 26. The outer casing 27 of the planet gear is fixed to a housing in a non-rotatable manner.

The planets 25 are interconnected by a carrier 28 in which the planets 25 are rotatably suspensioned in spherical roller bearings 1 according to the present invention - please note that all the planets 25 are suspensioned in such bearings even though fig. 13 only indicates that one of the planets has such a bearing. The sun 26 may also advantageously be suspensioned by one or more roller bearings according to the present invention.

The axis of rotation of the planets 25 is tilted typically around 6°, as indicated in fig. 12 resulting in that the gravity acts on the rows of each roller bearing which in case traditional bearings were used would result in a dislocation of one of the rows to a position where rollers are wedged between the inner and outer rings of the bearing as described in the beginning of this text and illustrated schematically in fig. 15a and 15b.

However, in transmissions according to the present invention, the wind turbine transmission 19 and in particular the suspension of the planets 25 of the planet gear is provided with spherical roller bearings according to the present invention.

As wedging of rollers is most pronounced in bearings rotating with a relatively low rotational speed it is preferred that all the bearings in the transmission rotating with a low rotational speed are spherical roller bearings according to the present invention.

Furthermore, the shaft connecting the high speed side of the transmission with the generator is preferably also suspensioned by roller bearings according to the present invention. Additionally, the main shaft 20 may also advantageously be suspensioned by roller bearings according to the present invention.

In fig. 16a a seventh embodiment of a roller bearing is shown. The roller bearing is structurally similar to other embodiments of the invention and comprises an outer ring 3, an inner ring 2, two rows of spherical rollers 4a and 4b, a holding structure 6a and 6b and a distance piece 11. Arrow D indicates a tilting force originating e.g. from gravity. In preferred embodiments the holding structure is adapted to prevent tilting of the rollers.

In order to control the movement of the two rows of rollers in axial direction away from each other, the roller bearing is provided with a limiting ring 31, preferably considered to be an element of the holding structure, on each side of the bearing. These limiting rings 31 contact the rollers on theirs outer end as indicated in fig. 16a thereby limiting the axial movement of the rollers in the direction out of the bearing to avoid wedging of the rollers between the inner and outer rings 2, 3.

In general roller bearings are manufactured with such dimensions that a gap is present between rollers and the outer ring 3 when the rollers abut the inner ring 2 (or between the rollers and the inner ring in case the rollers abut the outer ring 3). This is indicated by numeral 33 in fig. 16a in relation to the preferred embodiment of that figure. The dimensions and/or arrangement of the holding structure in bearings according to the present invention may preferably be chosen such that when the inner ring, the outer ring, and the rollers are arranged relatively to each other as shown in fig. 16a, then the gap is not closed due to axial movement, if any, in axial direction away from each other of the two rows of rollers.

An example of this is shown in fig. 16a wherein the limiting rings 31 are preferably designed so that the axial movement of the rollers is limited due to the rollers contacting the outer ring 31 (indicated by arrow C in fig. 16a) before the rollers contact the outer ring 3 as indicated in fig. 16a by a small tolerance - a gap 33 - between the rollers and the outer ring 3. As shown in fig. 16b, the limiting rings may each be provided with holes 32 for allowing oil to be communicated at least between the exterior of the bearing and the raceways of the inner ring 2.

The seventh preferred embodiment is particular useful at least in the sense that such limiting rings 31 may be applied to roller bearings which originally where designed and produced without a holding structure adapted to control movement of the two adjacent rows of rollers at least in axial direction away from each other.

As an alternative to providing limiting rings 31 as separate parts of the bearing, the limiting ring may be provided integral with the bearing, for instance by manufacturing the inner ring 2 with an edge provided at the axial outer most part of the inner ring 2.

A gap like the gap 33 may introduce the risk that the rollers are tilted and thereby wedged between the inner and outer rings. This risk is increased in situations where the diameter of the rollers is large compared to the width of the rollers. The force seeking to tilt the rollers may stem from the gravity acting on the rollers as indicated on fig. 16a, if the height of the ring 31 is small.

Such tilting, and thereby also the wedging following therefrom, is prevented by the limiting rings 31 as these in co-operation with the distance piece 11 seek to keep the rollers in substantially the same axial and tilting position relative to the inner ring 2.

A further alternative to the seventh embodiment - an eighth preferred embodiment is shown in fig. 17. In this embodiment the limiting rings 31 are arranged on the outside of the inner rings and comprise a circular disc having a bend 31a pointing inwardly and abutting the rollers as indicated in fig. 17.

An ninth preferred embodiment of the present invention is shown schematically in fig. 18 and is to some extend similar to the seventh embodiment and the reference numbers of figs. 16 and 17 are accordingly maintained for similar elements.

In the ninth embodiment, the parts of the holding structure labelled 6a and 6b are arranged below the longitudinal rotational axis of the rollers 4 and the distance piece 11 is elevated arranged. The limiting rings 31 each comprises an abutment piece 31a arranged so that it abuts the rollers above the longitudinal rotational axis of the rollers 4. This configuration is believed to provide an excellent security against tilting of the rollers. Furthermore, the limiting rings 31 may be applied to bearing which originally did not contain such rings.

It is noted that the limiting rings of the seventh and eighth embodiments may equally well be arranged on the outer ring 3 instead of on the inner ring 2 in cases where the geometry of the raceways of the inner and outer rings is inverted, i.e. the raceways of the inner ring is single circular and the raceways of the outer ring is double circular.

CLAIMS

1. A spherical roller bearing comprising

- an outer ring and an inner ring each being provided with confronting raceways,
- two rows of rollers arranged adjacent to each other in the annular space between the raceways;

and

- a holding structure adapted to controlling, such as preventing, movement of the two adjacent rows of rollers at least in axial direction away from each other.

2. A spherical roller bearing according to claim 1, wherein the holding structure comprises a roller cage for each row of rollers, circumferential spacing the rollers in each row and keeping the rollers in a substantial fixed position relatively to the roller cage while at the same time allowing rotation of the rollers.

3. A spherical roller bearing according to claim 1 or 2, wherein the holding structure comprises an assembling ring co-operating with the roller cages, or at least a part thereof, to control movement of the roller cages relatively to each other at least in axial direction away from each other.

4. A spherical roller bearing according to any of the preceding claims, wherein each roller cage comprises circumferential distributed and radially extending inner projections abutting in an outward axial direction one or more members of the assembling ring thereby controlling the axial movement of the roller cages away from each other;

5. A spherical roller bearing according to claim 4, wherein the radially extending projections of the rollers cages extend also in axial direction towards the outer periphery of the bearing.

6. A spherical roller bearing according to claim 4 or 5, wherein the one more members of the assembling ring comprises two radially extending flanges defining a groove in which the radially extending projections of both roller cages extend into or within.

7. A spherical roller bearing according to any of claims 4-6, wherein the radially extending inner projections extend radially outwards.

8. A spherical roller bearing according to any of claims 4-6, wherein the radially extending inner projections extend radially inwards.

9. A spherical roller bearing according to any of claim 4-8, wherein the assembling ring is shaped so as to serve also as a distance piece keeping the two rows of rollers apart.

10. A spherical roller bearing according to any of the claims 1-3, wherein each roller cage comprises a radially extending inner flange co-operating with the assembling ring to

control the axial movement of the roller cages relatively to each other in axial direction away from each other, said inner flanges are preferably un-broken or slotted in radial direction.

11. A spherical roller bearing according to claim 10, wherein the assembling ring comprises an annular member having two rows of projections extending radially and abutting the inner flanges of the roller cages.

12. A spherical roller bearing according to claim 11, wherein the annular member of the comprises elongated slots, such as cut-outs.

13. A spherical roller bearing according to claim 11 or 12, wherein the radially extending projections are arranged in the vicinity of the elongated slots.

14. A spherical roller bearing according to any of claims 10-13, wherein the assembling ring extends in a curved manner in circumferential direction.

15. A spherical roller bearing according to any of the claims 10-14, wherein the projections of one or the rows of projections are circumferential staggered relatively to projections of the other row of projections.

16. A spherical roller bearing according to any of the claims 10-14, wherein the projections of one or the rows of projections are circumferential non-staggered relatively to projections of the other row of projections.

17. A spherical roller bearing according to any of claims 10-16, wherein the radially extending inner flanges of the roller cages extend radially outwards.

18. A spherical roller bearing according to any of claims 10-16, wherein the radiallly extending projections or the inner flanges of the roller cages extend radially inwards.

19. A spherical roller bearing according to claim 2, wherein the two roller cages engage with each other so as to control the axial movement of the roller cages away from each other in axial direction.

20. A spherical roller bearing according to claim 19, wherein the engagement of the two roller cages is provided by one of the roller cages comprises an inner groove, preferably defined by a fold, in which a flange of the other roller cage extends.

21. A spherical roller bearing according to claim 1, wherein the holding structure comprises a roller cage for both row of rollers circumferential spacing the rollers in each row and keeping the rollers in a substantial fixed position relatively to the roller cage while at the same time allowing rotation of the rollers.

22. A spherical roller bearing according to any of the claims 2-21, wherein the rollers are received in cut-outs being provided in the roller cages so as to keep the rollers in a substantial fixed position relatively to the roller cage while at the same time allowing rotation of the rollers.

23. A spherical roller bearing according to any of the preceding claims, wherein the two roller cages are made integral with each other.

24. A spherical roller bearing according to any of the preceding claims, wherein the holding structure comprises a limiting piece arranged on each side of the bearing, at least a part of the limiting rings abuts the end of the rollers to prevent movement of the two adjacent rows of rollers at least in axial direction away from each other.

25. A spherical roller according to claim 24, wherein the limiting rings are arranged in between the outer and inner rings.

26. A spherical roller according to claim 24, wherein the limiting rings are arranged on the outside of either the inner ring or the outer ring.

27. A spherical roller bearing according to any of the preceding claims, wherein the dimensions and/or arrangement of the holding structure is/are selected so that a gap being present between the rollers and the raceways of the outer and/or inner raceways when the outer and inner rings are arranged concentrically is not closed due axial movement, if any, in axial direction away from each other of the two rows of rollers.

28. A spherical roller bearing according to any of the preceding claims, wherein the holding structure is adapted to allow a movement of the two adjacent rollers in axial direction away from each other being within 0,001 and 1,0 %, such as within 0,01 and 0,5 % of the width of the outer ring.

29. A transmission comprising at least a first gear for increasing or decreasing the rotational speed of a mechanical element, said transmission comprising a number of gear wheels whereof at least some of the gear wheels are suspensioned by one or more roller bearings according to any of the preceding claims.

30. A transmission according to claim 29, wherein the first gear is a planet gear wherein the planets are interconnected by a carrier and suspensioned by roller bearings according to any of the claims 1-28.

31. A transmission according to claim 29 or 30, wherein rotational parts of one or gear succeeding the first gear are suspensioned by roller bearings according to any of the claims 1-28.

32. A wind turbine comprising a rotor being connected to a transmission being connected to a generator, wherein said transmission is of a kind according to any of claims 29-31.

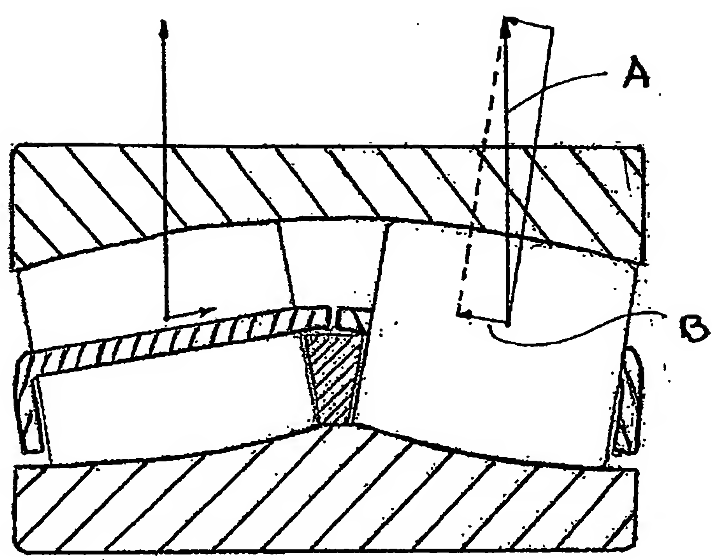

Fig. 1

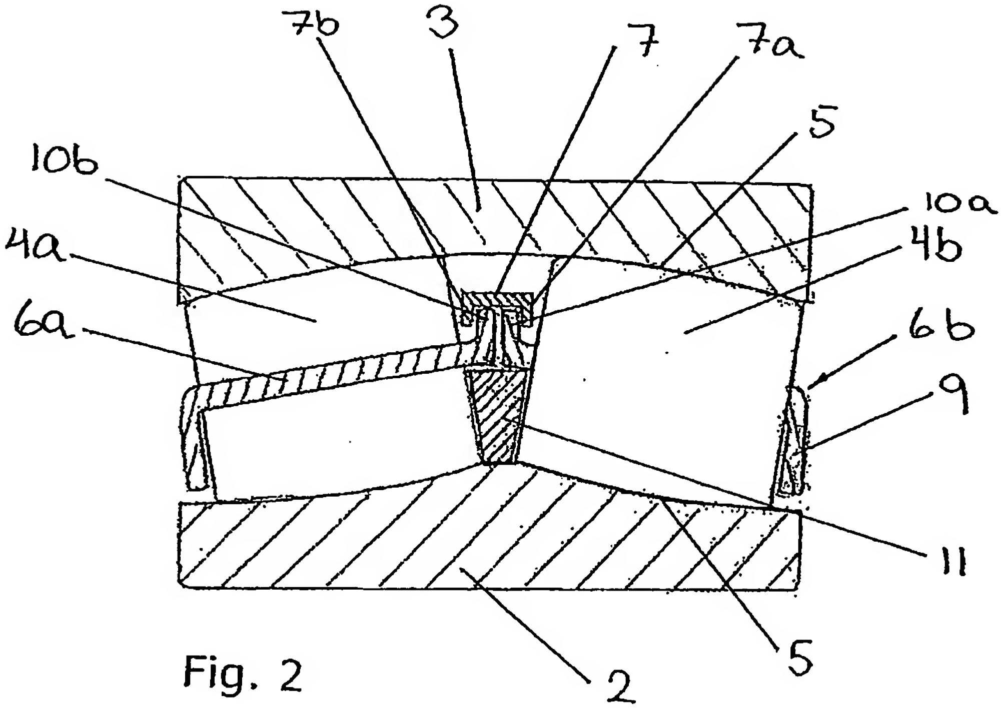

Fig. 2

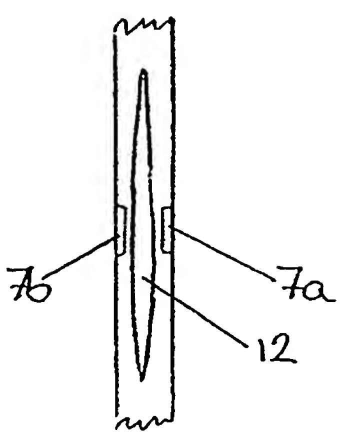

Fig. 3

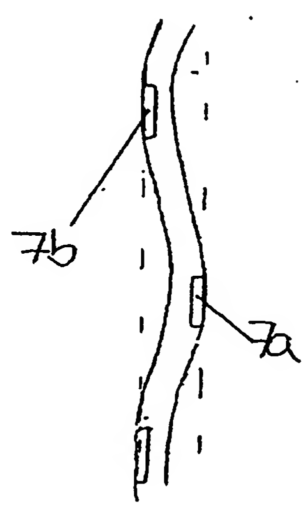

Fig. 4

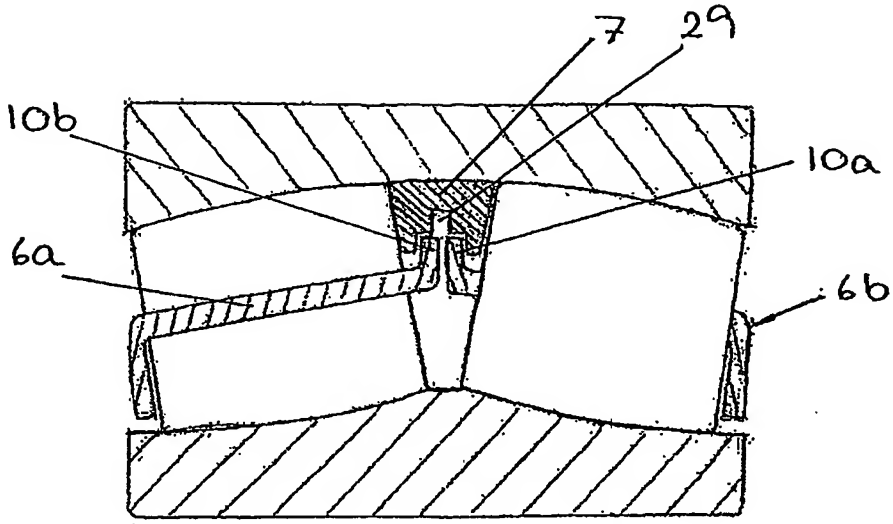

Fig. 5

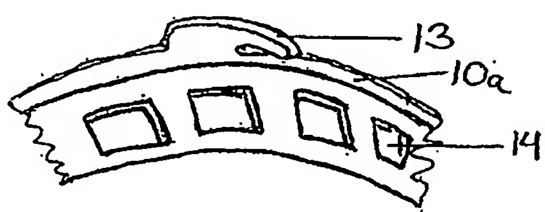

Fig. 6a

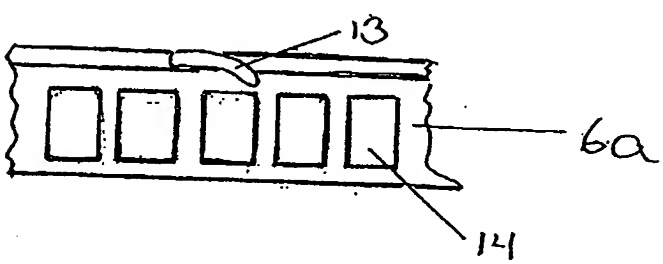

Fig. 6b

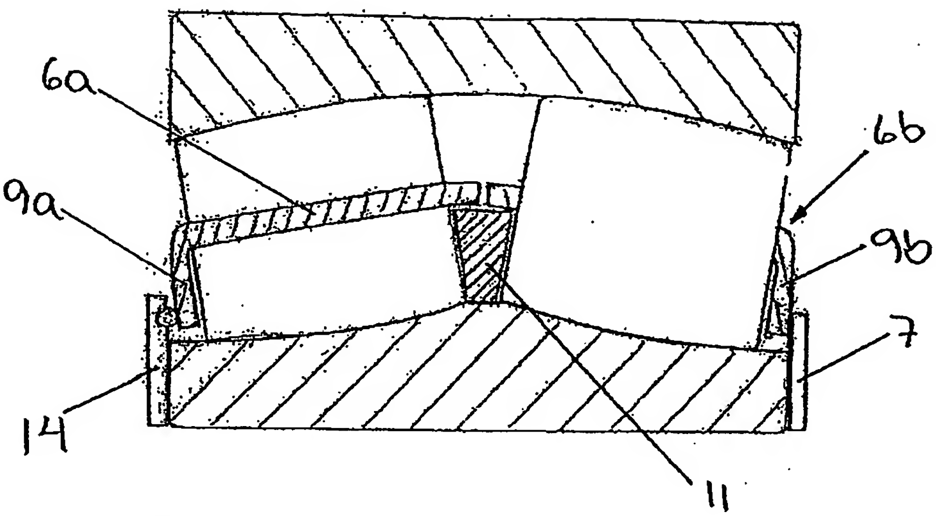

Fig. 7

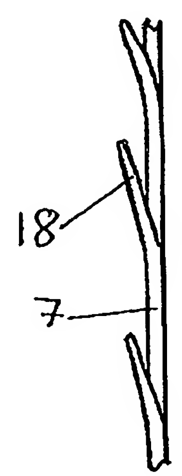

Fig. 8

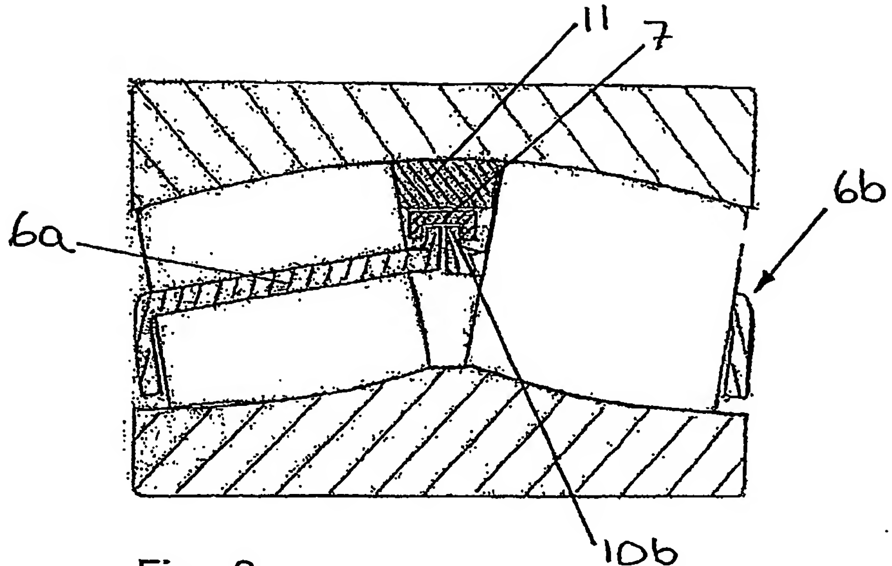

Fig. 9

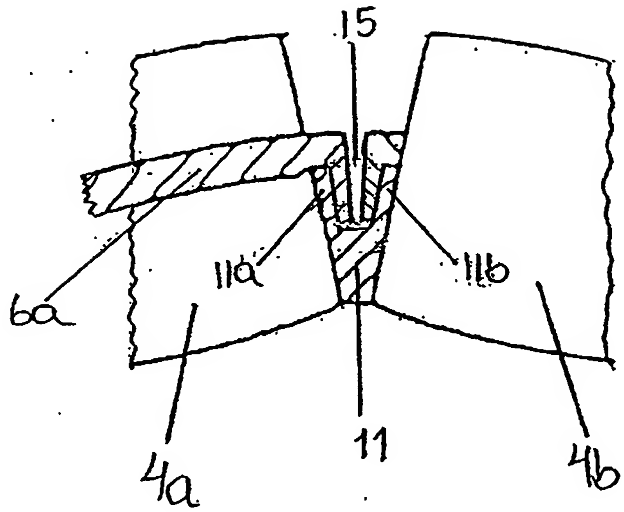

Fig. 10

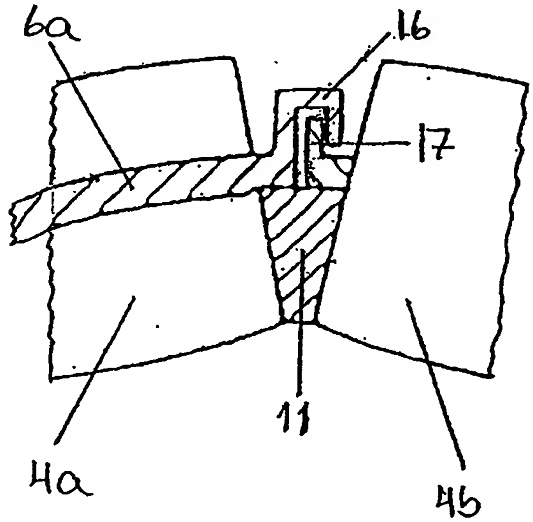

Fig. 11

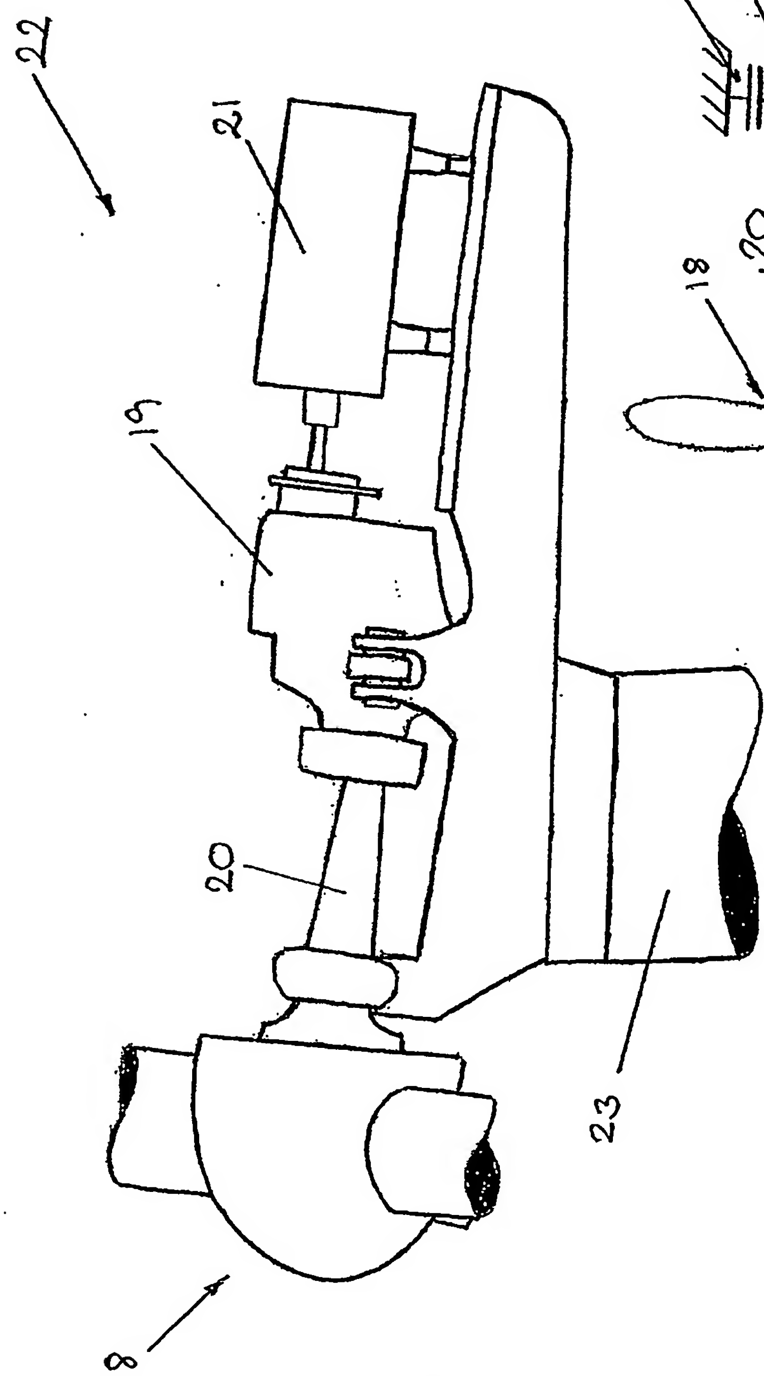

Fig. 12

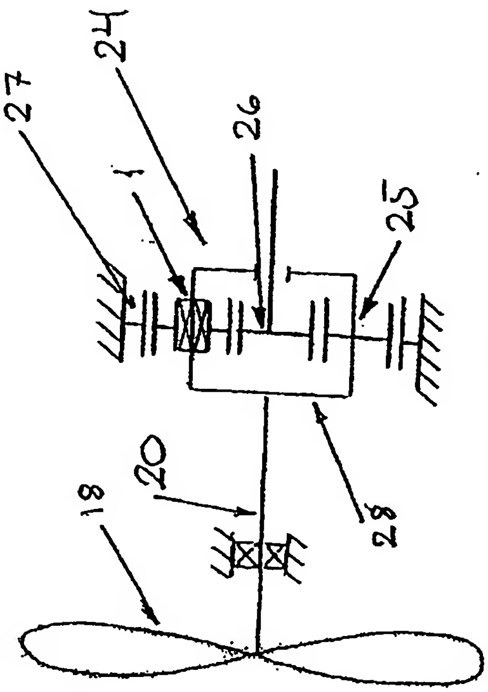

Fig. 13

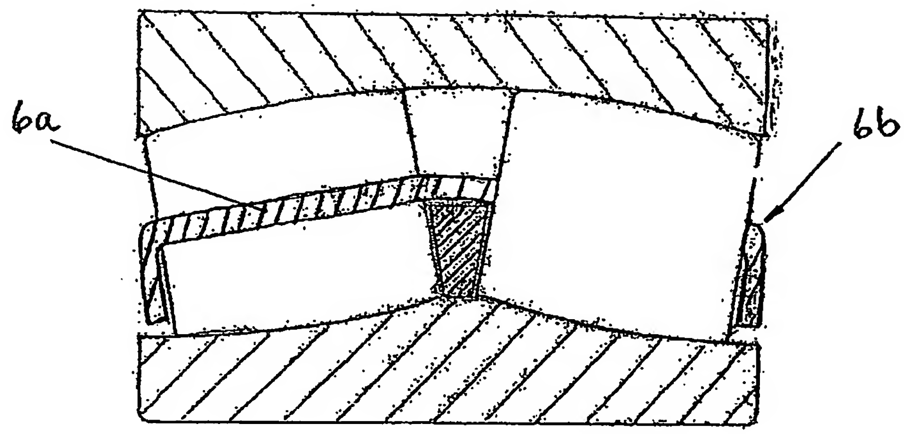

Fig. 14

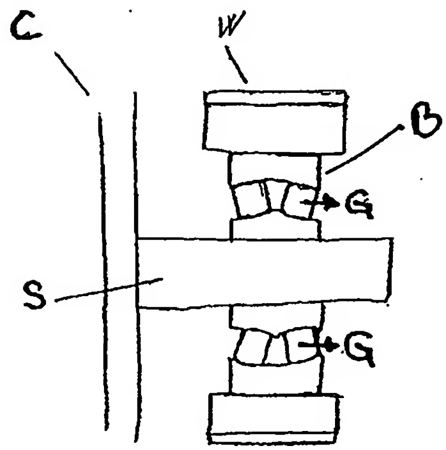

Fig. 15a

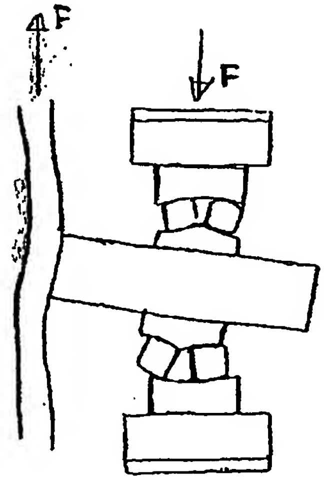

Fig. 15b

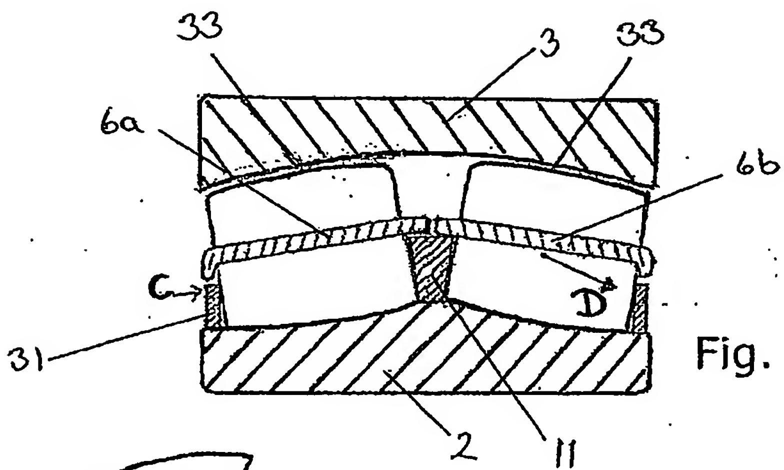

Fig. 16a

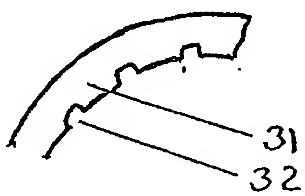

Fig. 16b

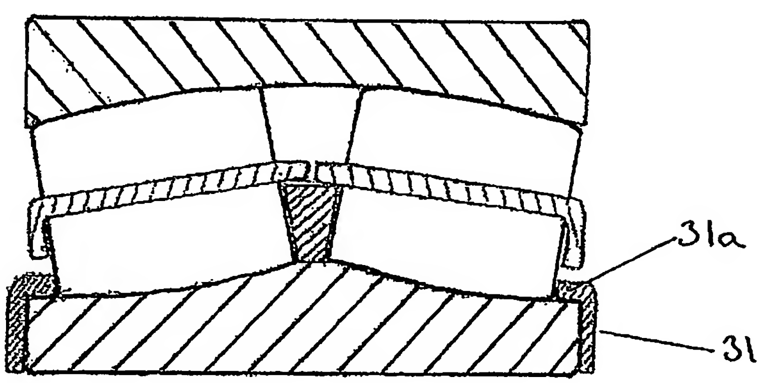

Fig. 17

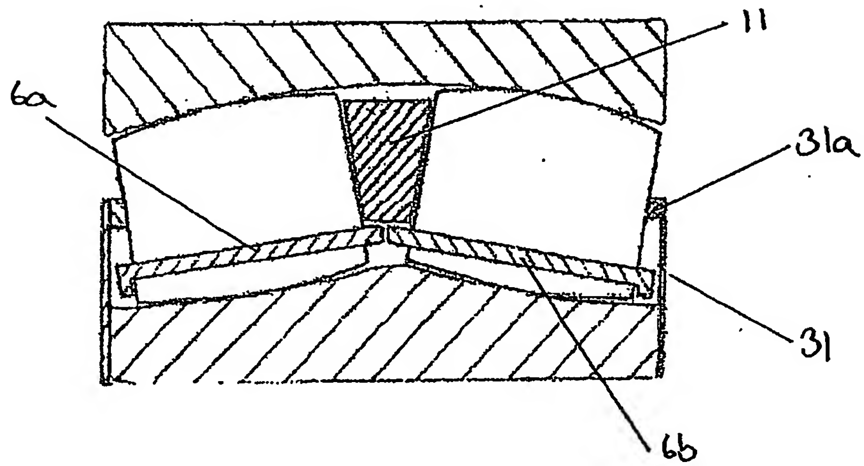

Fig. 18

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DK 03/00606

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16C33/48 F03D11/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16C F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 677 720 A (SHEPARD RICHARD W ET AL) 7 July 1987 (1987-07-07) abstract; figures 1-18	1-28
Y		29-32
X	US 4 522 516 A (NEESE GERHARD) 11 June 1985 (1985-06-11) abstract; figures 1-7	1-28
Y		29-32
Y	WO 02 14690 A (HANSEN TRANSMISSIONS INTERNAT ;BOGAERT ROGER (BE); FLAMANG PETER () 21 February 2002 (2002-02-21) abstract; figures 1-9	29-32

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2003	08 JAN 2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	JAN-AXEL YLIVAINIO/JAA

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/DK 03/00606

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